GRAVITY PROBE B
PROCEDURE FOR
SCIENCE MISSION DEWAR

Spacecraft Battery Magnetic Field Survey

This operation to be performed in VAFB building 1610

THIS DOCUMENT CONTAINS NON-HAZARDOUS OPERATIONS

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P1069 Rev-

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Revision Record

REVISION	ECO	PAGES	DATE

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List of Abbreviations and Acronyms

AG-x	Gauge x of Gas Module auxiliary section
AMI	American Magnetics Inc.
ATC	Advanced Technology Center
AR	As required
Aux	Auxiliary
AV-x	Valve x of Gas Module auxiliary section
Bot	Bottom
CN [xx]	Data acquisition channel number
DAS	Data Acquisition System
DR	Discrepancy Report
EG-x	Gauge x of Gas Module exhaust section
EM	Electrical Module
ERV-x	Relief valve of Gas Module exhaust section
EV-x	Valve number x of Gas Module exhaust section
FCV	Fill Cap Valve
FIST	Full Integrated System Test
GHe	Gaseous Helium
GM	Gas Module
GP-B	Gravity Probe-B
GSE	Ground Support Equipment
GT	Guard Tank
GTVC	Guard Tank Vent Cap
GTVC-G	Guard Tank Vent Cap pressure gauge
GTVC-RV	Guard Tank Vent Cap relief valve
GTVC-V	Guard Tank Vent Cap valve
GTV-G	Guard Tank vent pressure gauge
GTV-RV	Guard Tank vent relief valve
GTV-V	Guard Tank vent valve
HX-x	Vent line heat exchanger in Gas Module
KFxx	Quick connect o-ring vacuum flange (xx mm diameter)
LHe	Liquid Helium
LHSD	Liquid Helium Supply Dewar
Liq	Liquid
LL	Liquid level
LLS	Liquid level sensor
LMMS	Lockheed Martin Missiles and Space
MT	Main Tank
MTVC	Main Tank Vent Cap
MTVC-G	Main Tank Vent Cap pressure gauge
MTVC-RV	Main Tank Vent Cap relief valve
MTVC-V	Main Tank Vent Cap valve
NBP	Normal boiling point
NASA	National Aeronautics and Space Administration
PFCG	Fill Cap assembly pressure Gauge
PFM	Pump equipment Flow Meter
PG-x	Gauge x of Pump equipment
PRT	Platinum Resistance Thermometry
psi	pounds per square inch
psig	pounds per square inch gauge
PTD	Payload Test Director
PV-x	Valve x of the Pump equipment
QA	Quality Assurance
QE	Quality Engineer
RGA	Residual Gas Analyzer
SMD	Science Mission Dewar
STV	SMD Thruster vent Valve
SU	Stanford University
SV-x	SMD Valve number x
TG-x	Gauge x of Utility Turbo System
TV-x	Valve x of Utility Turbo System
UTS	Utility Turbo System
VAFB	Vandenberg Air Force Base
VCP-x	Vent cap pressure gauge
VCRV-x	Vent cap relief valve
VCV-x	Vent cap valve
VDC	Volts Direct Current
VF-x	Liquid helium Fill line valve
VG-x	Gauge x of Vacuum Module
VM	Vacuum Module
VV-x	Valve x of Vacuum Module
VW-x	Valve x of Dewar Adapter

LV-x	Large Vatterfly-x

A. SCOPE

This procedure describes the steps necessary to measure the magnetic field produced by the GP-B Spacecraft battery using an APS three-axis magnetometer. In addition, it provides the steps necessary to generate a magnetic field identical in magnitude to the measured field and to monitor the payload SQUID and magnetometer response.

B. SAFETY

B.1. Potential Hazards

Personal injury and hardware damage can result during normal positioning, assembly and disassembly of hardware.

Liquid helium used in the SMD represents a hazardous material for the personnel involved in the operations. Cryogenic burns can be caused by contact with the cold liquid or gas, high pressures can result if boiling liquid or cold gas is confined without a vent path, and asphyxiation can result if the vent gas is allowed to accumulate.

The SMD Safety Compliance Assessment, document GPB-100153C and the Missile System Prelaunch Safety Package LM/P479945 discuss the safety design, operating requirements and the hazard analysis of the SMD.

B.2. Mitigation of Hazards

B.2.1. Lifting hazards

There are no lifting operations in this procedure

B.2.2. Cryogenic Hazards

In VAFB building 1610, there may be an oxygen deficiency monitor that alarms when the oxygen level is reduced to 19.5%. In addition, the GP-B cryogenic team provides an oxygen deficiency monitor that alarms when the oxygen level is reduced to 19.5%. Appropriate action(s) to be taken in the event of oxygen deficiency monitor alarming at 19.5% (evacuation, safety verification of acceptable O2, etc) Additional temperature and pressure alarms, provided by the DAS, warn of potential over-pressure conditions. Emergency vent lines are installed over the four burst disks to direct any flow to an outside area.

Only authorized and trained personnel are allowed in VAFB facilities without escort. All personnel working on platforms at a height 30 inches or more off the floor are required to have an approved air tank (emergency life support apparatus ELSA) within easy reach. Note that tank need not be kept available when working from ladder. In the unlikely event of a large Lhe spill all employees have been instructed to evacuate the room and proceed to designated fallback area Bldg 1605, and contact NASA safety.

The following additional requirements apply to all personnel involved directly in cryogenic operations. Gloves that are impervious to liquid helium and liquid nitrogen are to be worn whenever the possibility of splashing or impingement of high-velocity cryogens exists or when handling equipment that has been cooled to cryogenic temperatures. Protective clothing, non-absorbent shoes and full-face shields with goggles/glasses are to be worn whenever the possibility of splashing cryogens exists.

B.2.3. Other Hazards

All tools or other items used with the potential to damage the SMD or Probe shall be tethered.

B.3. Mishap Notification

B.3.1. Injury

In case of illness/injury requiring EMERGENCY medical treatment, **DIAL 911.**

B.3.2. Hardware Mishap

In case of an accident, incident, or mishap, notification is to proceed per the procedures outlined in Lockheed Martin Engineering Memorandum EM SYS229 and Stanford University GP-B P0879. Additionally, VAFB NASA Safety and 30th Space Wing Safety will be notified as required.

B.3.3. Contingency Response

Responses to contingencies (e.g., power failure) are listed in Appendix 3.

C. QUALITY ASSURANCE

C.1. QA Notification

The NASA representative and SU QA shall be notified 24 hours prior to the start of this procedure. Upon completion of this procedure, the QE Manager will certify his/her concurrence that the effort was performed and accomplished in accordance with the prescribed instructions by signing and dating in the designated place(s) in this document.

C.2. Red-line Authority

Authority to red-line (make minor changes during execution) this procedure is given solely to the PTD or his designate and shall be approved by the QA Representative. Additionally, approval by the Payload Technical Manager shall be required, if in the judgement of the PTD or QA Representative, experiment functionality may be affected. Within hazardous portions of this procedure, all steps shall be worked in sequence. Out-of-sequence work or redlines shall be approved by NASA Safety prior to their performance.

C.3. Discrepancies

A Quality Assurance Representative designated by D. Ross shall review any discrepancy noted during this procedure, and approve its disposition. Discrepancies will be recorded in a D-log or a DR per Quality Plan P0108. Any time a procedure calls for verification of a specific configuration and that configuration is not the current configuration, it represents a discrepancy of one of three types. These types are to be dealt with as described below.

1. If the discrepancy has minimal effect on procedure functionality (such as the state of a valve that is irrelevant to performance of the procedure) it shall be documented in the procedure, together with the resolution. Redlines to procedures are included in this category.
2. If the discrepancy is minor and affects procedure functionality but not flight hardware fit or function, it shall be recorded in the D-log. Resolution shall be in consultation with the PTD and approved by the QA representative.
3. All critical and major discrepancies, those that effect flight hardware fit or functions, shall be documented in a D-log and also in a Discrepancy Report, per P0108.

D. TEST PERSONNEL

D.1. Personnel Responsibilities

The performance of this procedure requires a minimum complement of personnel as determined by the Test Director. The Test Director is the designated signer for the “witnessed by” sign-off located at the end of each procedure. The person in charge of the operation (Test Director or Test Engineer) is to sign the “completed by” sign-off. The Test Director will perform Pre-Test and Post-Test Briefings in accordance with P0875 “GP-B Maintenance and Testing at all Facilities.” Checklists will be used as directed by P0875

D.2. Personnel Qualifications

The Test Director must have a detailed understanding of all procedures and facility operations and experience in all of the SMD operations. Test Engineers must have SMD Cryogenic operations experience and an understanding of the operations and procedures used for the cryogenic servicing/maintenance of the Dewar.

D.3. Required Personnel

The following personnel are essential to the accomplishment of this procedure:

FUNCTIONAL TITLE	NUMBER	AFFILIATION
Test Director/Test Engineer	1	Stanford
GP-B Quality Assurance	1	Stanford
NASA Safety Rep	1	SFAO or ANALEX

E. REQUIREMENTS

There are no lifting operations in this procedure

E.1. Hardware/Software Requirements

E.1.1. Commercial Test Equipment

No commercial test equipment is required for this operation.

E.1.2. Ground Support Equipment

The Ground Support Equipment includes the Gas Module, the Electrical Module. The Gas Module provides the capability to configure vent paths, read pressures and flow rates, and pump and backfill vent lines. The Pump Module provides greater pumping capacity than the Gas Module, together with additional flow metering capabilities. The vent output of the Gas Module flows through the Pump Module. The Electrical Module contains the instruments listed in Table 1, and provides remote control of valves in the Gas Module, Pump Module, and SMD.

E.1.3. Computers and Software:

The Data Acquisition System (DAS) is required for this procedure. The DAS reads and displays pressures, temperatures, and flow rates and monitors critical parameters. No additional computers or software are required.

E.1.4. Additional Test Equipment

Description
APS Fluxgate Magnetometer with 3-axis probe
8”magnetic field coil
HP Power Supply

E.1.5. Additional Hardware

Description
N/A

E.1.6. Tools

Description
N/A

E.1.7. Personnel Protective Equipment

1. N/A

E.1.8. Expendables

Description	***Quantity***	***Mfr./Part No.***
N/A	-	-

E.2. Configuration Requirements

E.2.1. Spacecraft battery magnetic field survey

The spacecraft must be drawing power from the battery during this test. In addition, the SQUID electronics should be powered on if possible

E.2.2. Spacecraft battery/SQUID interference test
The spacecraft must not be drawing power from the battery and should be powered through the Umbilical. The SQUID electronics and payload magnetometers must be on.

F. REFERENCE DOCUMENTS

F.1. Drawings

Drawing No.	*Title*
LMMS-5833394	Instrumentation Installation

F.2. Supporting documentation

Document No.	*Title*
LMMC-5835031	GP-B Magnetic Control Plan
GPB-100153C	SMD Safety Compliance Assessment
LM/P479945	Missile System Prelaunch Safety Package
SU/GP-B P0141	FIST Emergency Procedures
LMSC-P088357	Science Mission Dewar Critical Design Review
SU/GP-B P0108	Quality Plan
LMMS GPB-100333	Science Mission Dewar Failure Effects and Causes Analysis
SU/GP-B P059	GP-B Contamination Control Plan
EM SYS229	Accident/Mishap/Incident Notification Process
EWR 127-1	Eastern and Western Range Safety Requirements
KHB 1710.2 rev E	Kennedy Space Center Safety Practices Handbook

F.3. Additional Procedures

Document No.	*Title*
SU/GP-B P0879	Accident/Incident/Mishap Notification Process
SU/GP-B P0875	GP-B Maintenance and Testing at all Facilities

Operation Number:____________

Date Initiated:____________

Time Initiated:____________

G. OPERATIONS

G.1. Pre-Operations Verifications

- o Verify SU QA notified.

  Record: Individual notified __________________,

  Date/time ________/________.

- o Verify NASA representative notified.

  Record: Individual notified __________________,

  Date/time ________/________.

- o Verify completion of the Pre-Operations Checklist (Appendix 1).

QA Witness:____________

G.2. Spacecraft Battery Magnetic Field Survey

G.2.1. Ensure that power is being drawn from the spacecraft batteries and that it will continue to draw power from the batteries until the completion of the test.

1. Record current draw:____________A

G.2.2. Measure magnetic field below spacecraft battery pallet

Note:
Refer to Figure 1 for the following section.

1. Record ambient magnetic field background

   a. Away from any sources of magnetic fields, align the magnetometer with X, Y and Z axis of the vehicle and record the following

   b. X-axis field:___________

   c. Y-axis field:___________

   d. Z-axis field:____________

2. While aligning magnetometer with vehicle axis' below the battery pallet, record X, Y, and Z-axis fields in table 1. Record the field values for as many of the 144 points labeled in figure 1 as time allows.
    a. Record distance below battery pallet where measurements are made:___________

G.2.3. Record magnetic field along top (+Z) of battery pallet

1. While aligning magnetometer with vehicle axis' above (+Z) the batteries, record X, Y, and Z-axis fields per engineering direction
2. Record results in table 2 and fill in drawing 2 with the relevant locations of measurement points

G.2.4. Record magnetic field along –Y/+X side of batteries

1. While aligning magnetometer with space vehicle axis', record X, Y, and Z-axis fields for the –Y side of the batteries per engineering direction
2. Record results in table 3 and fill in drawing 3 with the relevant locations of measurement points

G.2.5. Record magnetic field along +Y/-X side of batteries

1. While aligning magnetometer with space vehicle axis', record X, Y, and Z-axis fields for the +Y side of the batteries per engineering direction
2. Record results in table 4 and fill in drawing 4 with the relevant locations of measurement points

G.2.6. Record magnetic field along –Y/+X side of batteries

1. While aligning magnetometer with space vehicle axis', record X, Y, and Z-axis fields for the –X side of the batteries per engineering direction
2. Record results in table 5 and fill in drawing 5 with the relevant locations of measurement points

Note:
It is not possible to axis the +X side of the batteries

QA Witnesss:___________

G.3. **Induce Magnetic Field and Monitor SQUID and payload magnetometer response.**

1. Ensure space vehicle to powered via the UIS and not the battery
2. Ensure SQUID electronics and payload magnetometers are powered up and operating
3. Monitor SQUID and payload magnetometer response
4. Record highest magnetic field and location found in section G.3
    a. Field:________
    b. Location:_______
5. Position field coil below battery pallet
6. Connect field coil to HP power supply
7. Record transfer function used
    a. Amp/Gauss:__________
8. Set current and voltage on HP power supply to generate a field below the battery pallet equal in magnitude to that record in G.3.1
9. Record settings
    a. Voltage (V):________
    b. Current (A):________
10. Using APS magnetometer, record magnetic field generated by field coil
    a. X-axis:________
    b. Y-axis:________
    c. Z-axis:_________
    d. Ensure field is as expected
11. Monitor SQUID and payload magnetometer response
12. At test directors direction, remove field coil and power supplies

G.4. Final Verifications

G.4.1. Verify completion of post-operations checklist.

Completed by:______________________

Completed by:______________________

Witnessed by:______________________

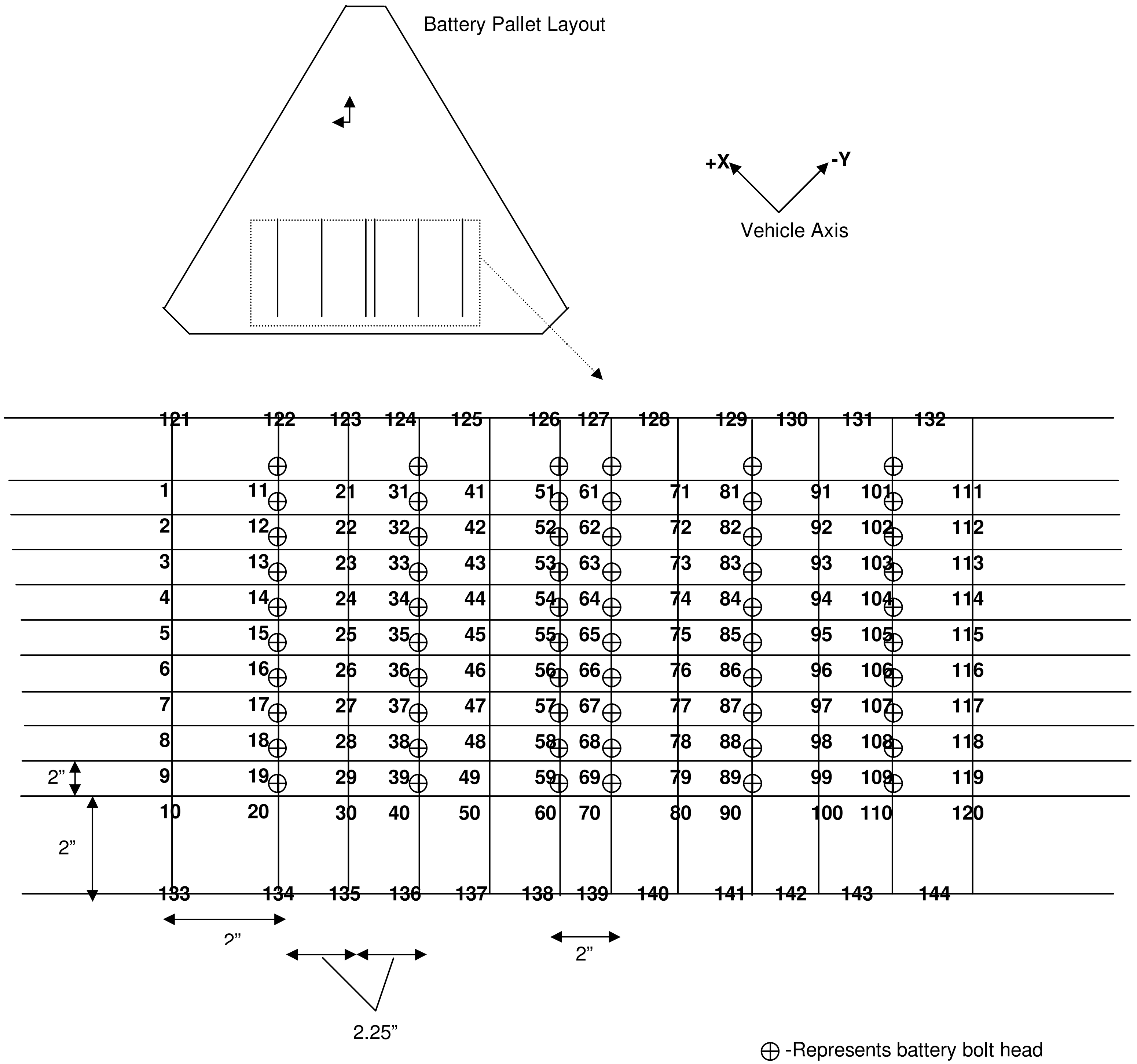
Date: __________

Time:__________

Quality Manager____Date_________________

Payload Test Director____________________________________Date_________________

Figure 1 GP-B Spacecraft Battery Pallet Layout (bottom side, drawing not to scale)



Appendix 1 **Pre Operations Checklist**

DATE	CHECKLIST ITEM	COMPLETED	REMARKS
	1. Verify the test procedure being used is the latest revision.		
	2. Verify all critical items in the test are identified and discussed with the test team.		
	3. Verify all required materials and tools are available in the test area.		
	4. Verify all hazardous materials involved in the test are identified to the test team.		
	5. Verify all hazardous steps to be performed are identified to the test team.		
	6. Verify each team member is certified and knows their individual responsibilities.		
	7. Confirm that each test team member clearly understands that he/she has the authority to stop the test if an item in the procedure is not clear.		
	8. Confirm that each test team member clearly understands that he/she must stop the test if there is any anomaly or suspected anomaly.		
	9. Notify management of all discrepancy reports or d-log items identified during procedure performance. In the event an incident or major discrepancy occurs during procedure performance management will be notified immediately.		
	10. Confirm that each test team member understands that there will be a post-test team meeting.		
	Team Lead Signature: ______________________		

Appendix 2 **Post Operations Checklist**

DATE	CHECKLIST ITEM	COMPLETED	REMARKS
	1. Verify all steps in the procedure were successfully completed.		
	2. Verify all anomalies discovered during testing are properly documented.		
	3. Ensure management has been notified of all major or minor discrepancies.		
	4. Ensure that all steps that were not required to be performed are properly identified.		
	5. If applicable sign-off test completion.		
	Team Lead Signature: ______________________		

Appendix 3– **Contingency Responses**

Condition	Circumstance	Response
Temperature limits (CN 1 or 28) exceeded	Any time	Promote MT venting: Open SV-9 and/ or EV-9 as appropriate to increase MT venting
Burst disk rupture (MT/GT)	Any time	Evacuate room
Vatterfly valve cover below atmospheric	Any time	Consult Payload Test Director and Payload Technical Manager
Main Tank or Guard Tank liquid level falls below alarm limit	Any time	Configure Dewar and Fill as appropriate
Oxygen Monitor Alarm	Anytime	Evacuate Room
Liquid Nitrogen Spill	Anytime	Clear area until all spilled liquid has evaporated
High boiloff rate	Any time	Reduce pressure in vatterfly caps: Adjust UTS valving so as to begin pumping on caps

Table 1: Space Craft Battery Magnetic Field Measurement -Z

Position	X-Axis	Y-Axis	Z-Axis	Position	X-Axis	Y-Axis	Z-Axis
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

Table 1 Cont.

Position	X-Axis	Y-Axis	Z-Axis	Position	X-Axis	Y-Axis	Z-Axis

Table 1   cont

Table 2: Space Craft Battery Magnetic Field Measurement +Z

Position	X-Axis	Y-Axis	Z-Axis	Position	X-Axis	Y-Axis	Z-Axis

Figure 2

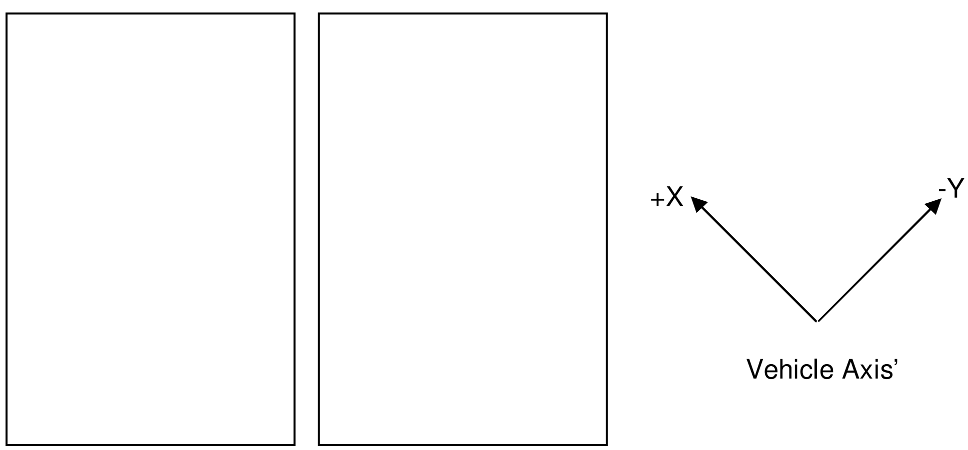


Table 3: Space Craft Battery Magnetic Field Measurement –Y/-X

Position	**X-Axis**	**Y-Axis**	**Z-Axis**	**Position**	**X-Axis**	**Y-Axis**	**Z-Axis**

Figure 3:

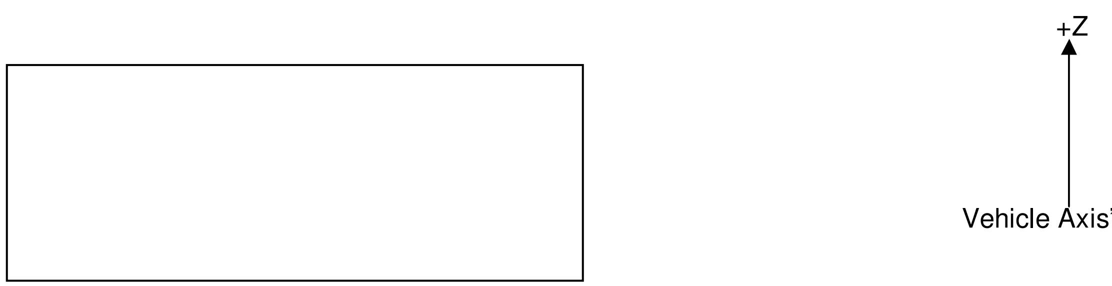


Table 4: Space Craft Battery Magnetic Field Measurement –X/+Y

Position	X-Axis	Y-Axis	Z-Axis	Position	X-Axis	Y-Axis	Z-Axis

Figure 4

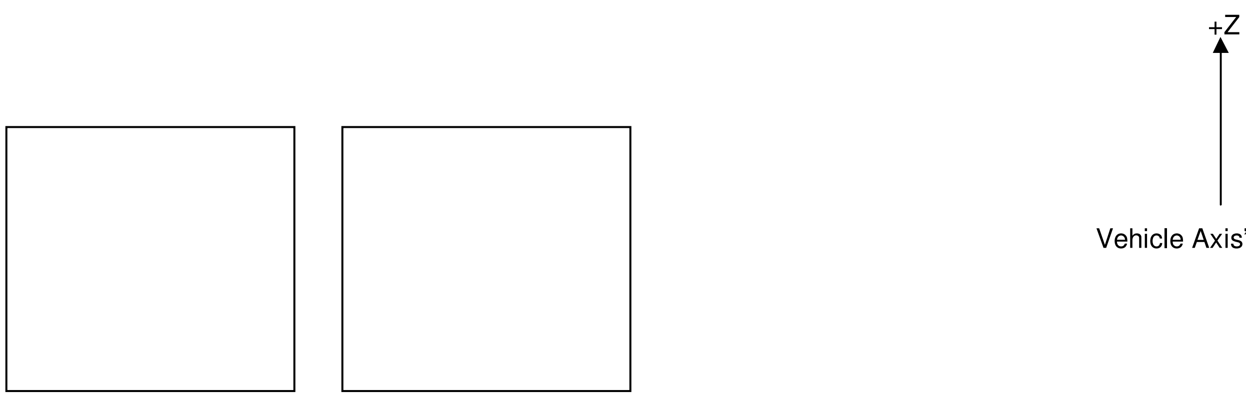


Table 5: Space Craft Battery Magnetic Field Measurement –Y/+X

Position	**X-Axis**	**Y-Axis**	**Z-Axis**	**Position**	**X-Axis**	**Y-Axis**	**Z-Axis**

Figure 5: